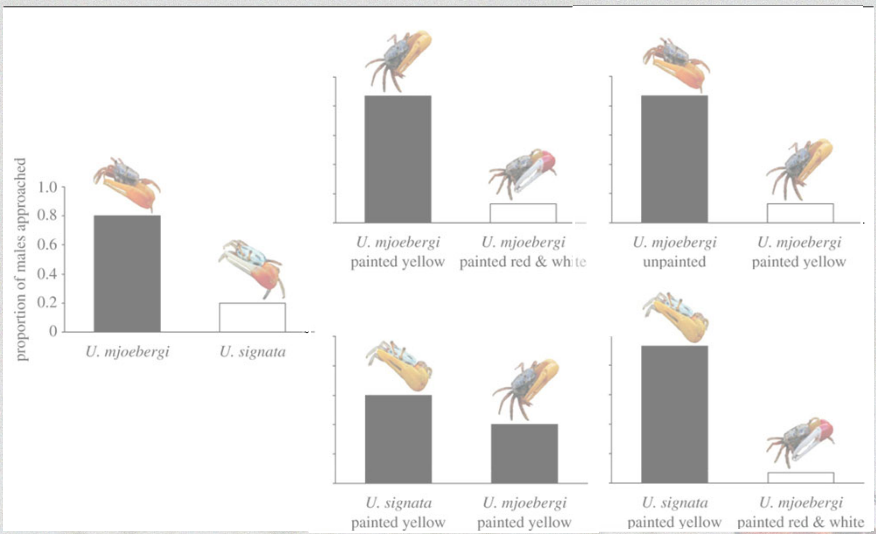
Information: Species recognition in fiddler crabs

Species recognition in fiddler crabs

behavioural discrimination experiments

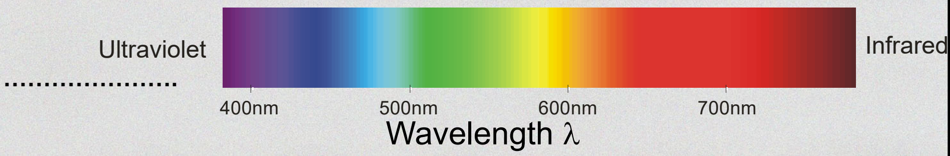


Detto et al 2006 Proc. R. Soc. B

What is colour?

Light of different wavelength has different colours

(Human) visible light

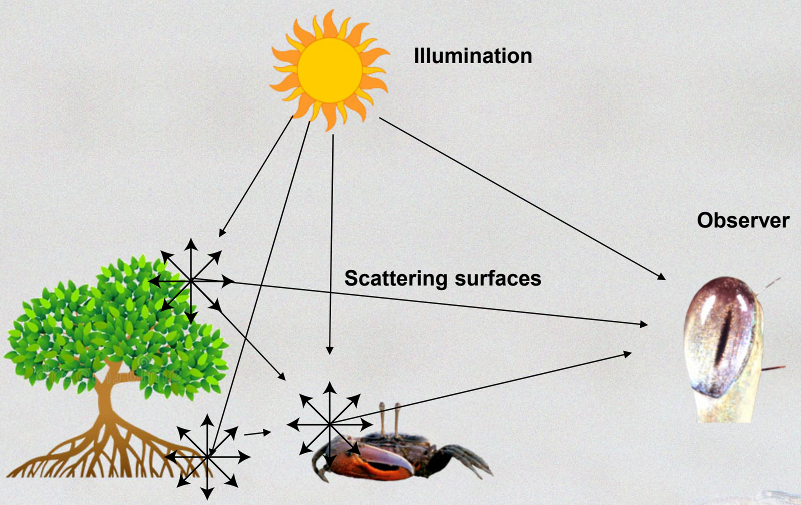


Light: Intensity - Wavelength - Polarisation

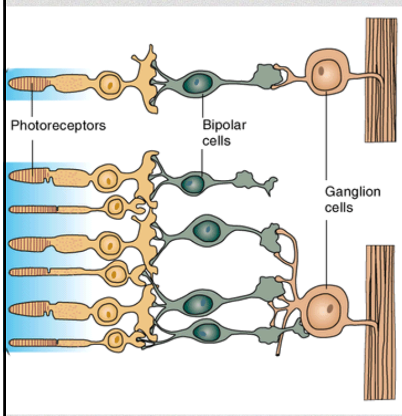
Jan Hemmi, School of Biological Sciences

What is colour?

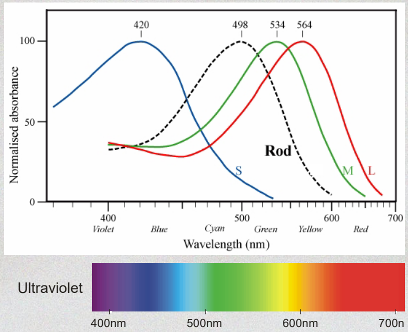
Colour is a reconstruction of the reflection properties of objects



Sampling the light

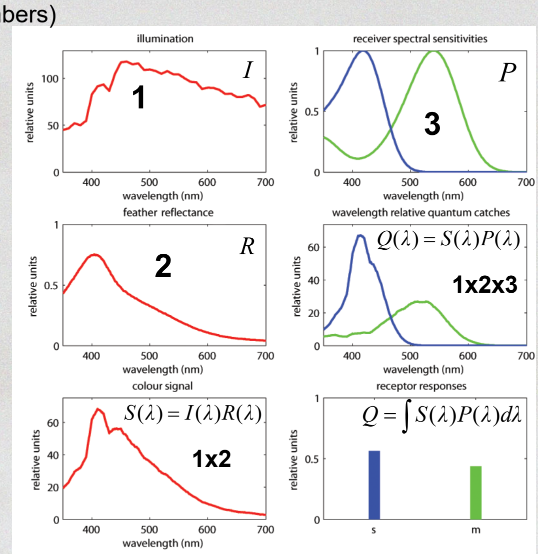


Spectral sensitivity curves of human photoreceptors



The information animals have to work with:

Calculating receptor quantum catches (lots of information gets reduced to single numbers)



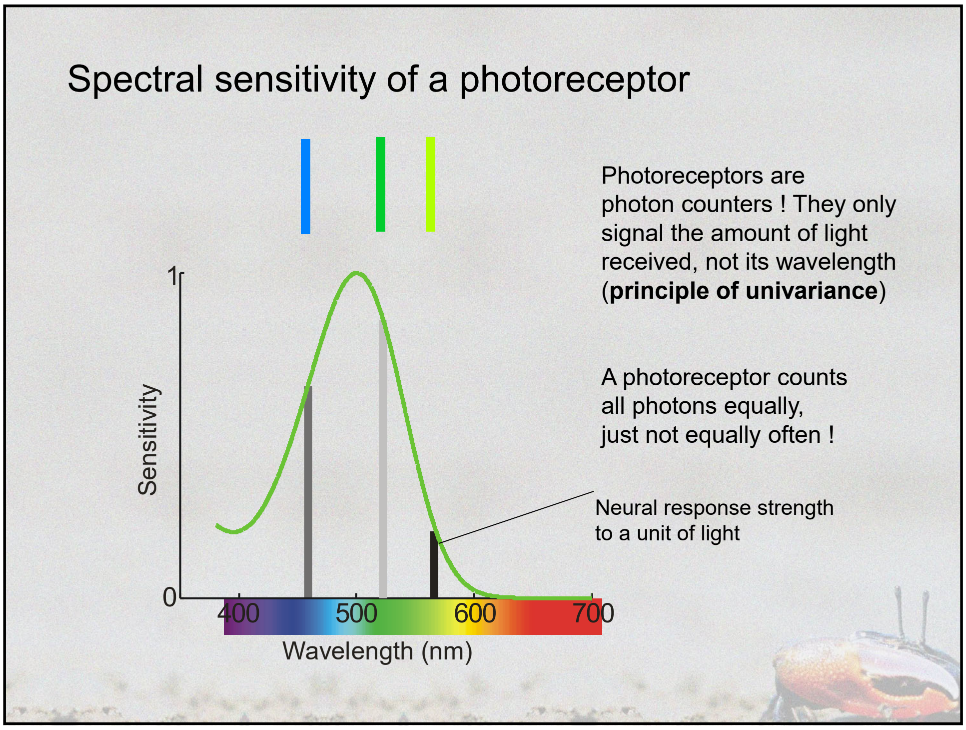
tammar wallaby

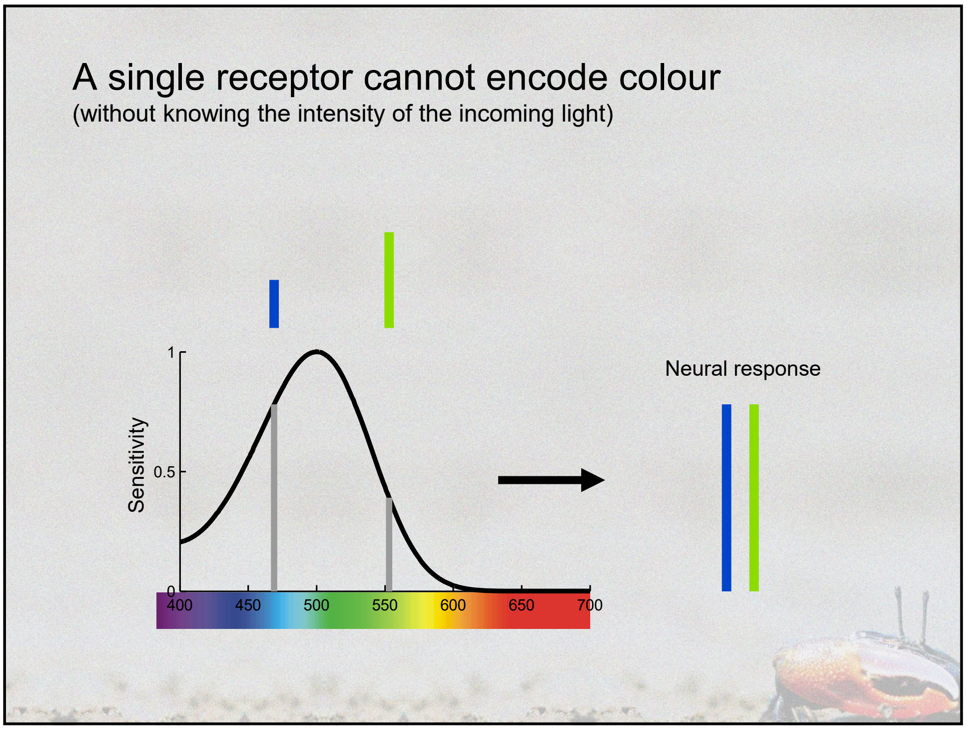
1: Illumination

2: Object

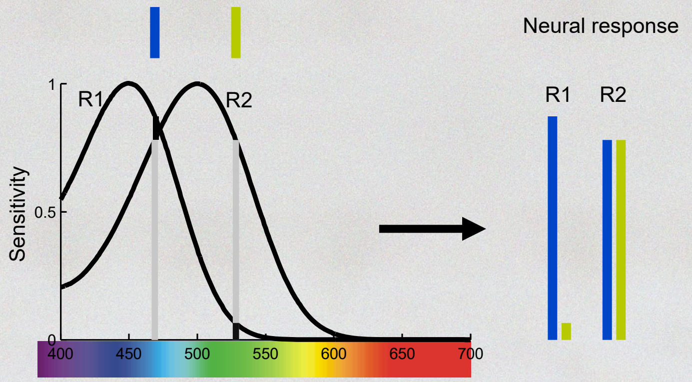
3: Observer

Q: Photoreceptor quantum catches

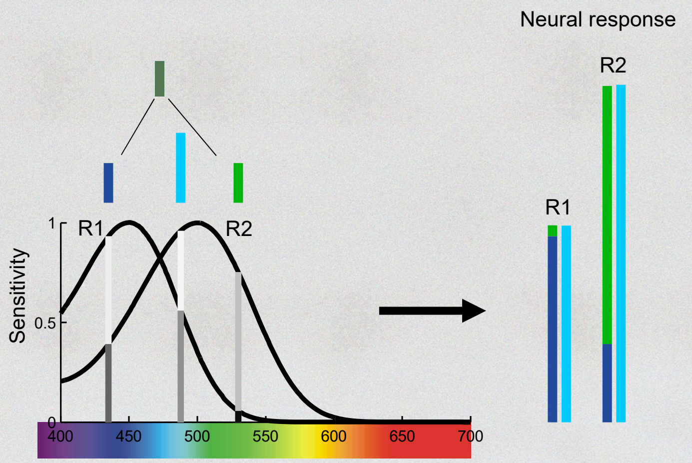

Spectral sensitivity of a photoreceptor
Photoreceptors are photon counters ! They only signal the amount of light received, not its wavelength (principle of univariance)
A photoreceptor counts all photons equally, just not equally often !
Neural response strength to a unit of light
Sensitivity
1
0
400
500
600
700
Wavelength (nm)


A single receptor cannot encode colour
(without knowing the intensity of the incoming light)
Neural response
Sensitivity
1
0.5
0
400
450
500
550
600
650
700

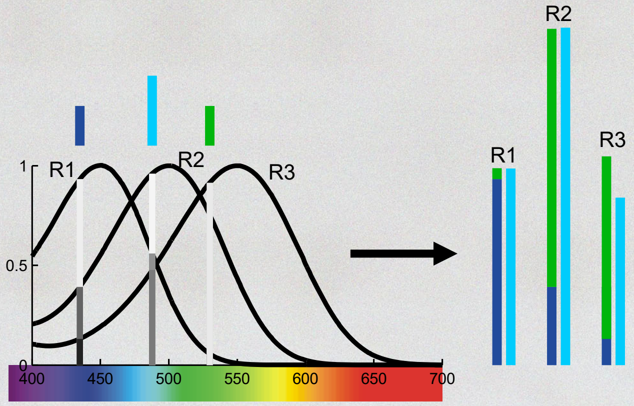
But two can …



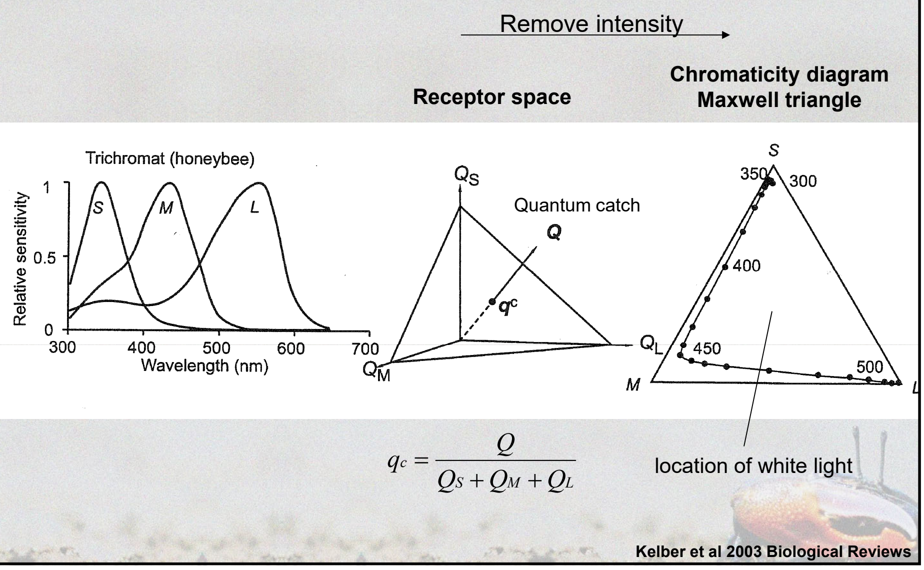
… sometimes (You can always find a combination of two colours that match a third colour)



Three are more accurate and cover a wider range …



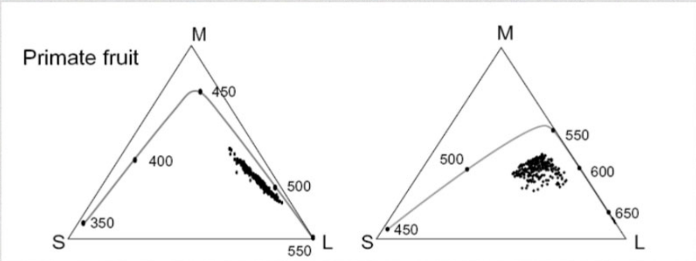
Trichromatic colour space



$$q_c = \frac{Q}{Q_S + Q_M + Q_L}$$

The similarity of colours: primate fruit in primate and bee eyes

Chromaticity diagrams: The vertices correspond to pure excitation of each of the three cone types

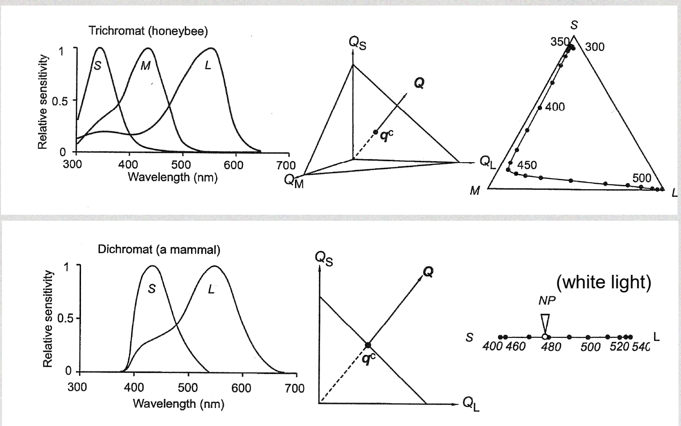


bee human

Osorio & Vorobyev 2008 Vision Res

Dichromatic colour space

Receptor space Chromaticity diagram



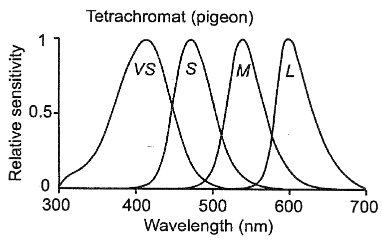
2-dimensional colour space (hue and saturation)

1-dimensional colour space

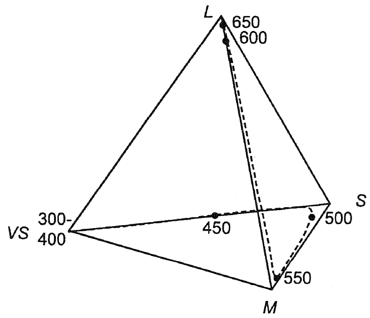
$$q_c = \frac{Q}{Q_S + Q_L}$$

Kelber et al 2003 Biological Reviews

Tetrachromatic colour space



Chromaticity diagram



Kelber et al 2003 Biological Reviews

The main concepts

- Colours are subjective! Their perception depends on the neural apparatus which is used to see them
- Photoreceptors are photon counters. They don't see colour. You have to compare the output from at least two types to see colour (colour opponent mechanisms).
- The dimensionality of an animal's chromaticity space has one less dimension than the number of its cone photoreceptors (e.g. one-dimensional for a dichromat). Its dimensionality determines how many primary colours (such as RGB computer colours) are needed to match any colour the animal can perceive)